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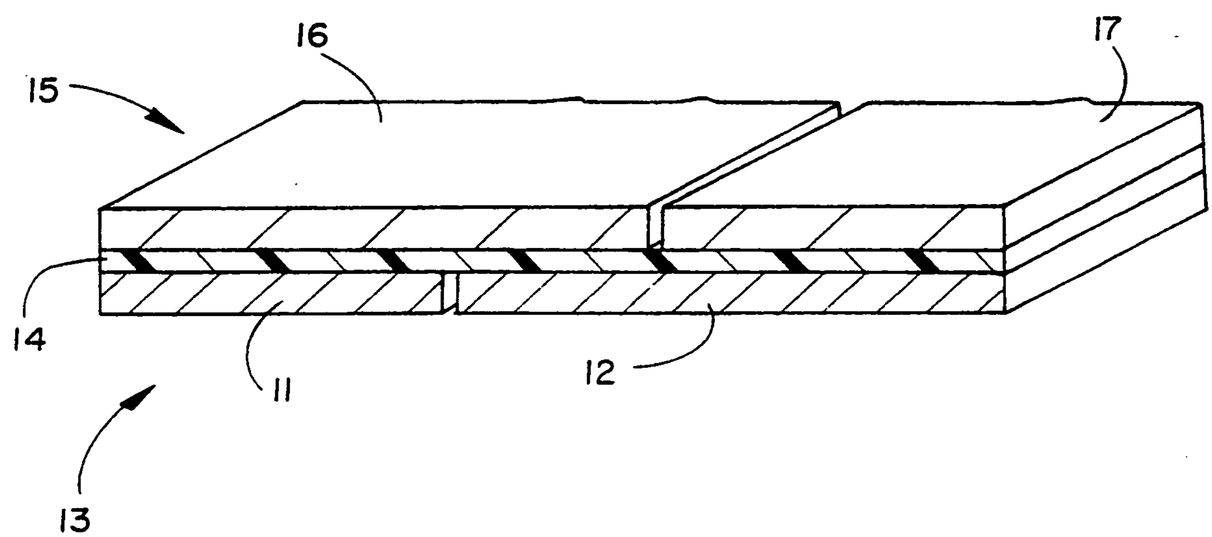

(57) Abstract

A laminated amorphous metal strip has a first layer (13) with at least two side-by-side strips of amorphous metal (11, 12) of unequal widths, and a second layer (15) with at least two side-by-side strips of amorphous metal (16, 17) of unequal widths, the layers being in reverse order with respect to the widths of the strips such that the wider strips overlap and form a brickwork cross-section pattern. A flexible polymeric bonding material (14) is disposed between the layers. This structure is illustrated in the drawing. A method for fabricating the laminated strip of amorphous metal includes providing rolls of metal, positioning the rolls in strips having differing widths, applying the bonding material, applying pressure while advancing the laminate, and cutting the laminate.

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LAMINATED STRIPS OF AMORPHOUS METAL

Technical Field

The present invention relates to strips of amorphous metal laminated and bonded with a polymeric material, and more particularly, to fabrication of a transformer coil.

Background Art

United States Patent No. 4,615,106 issued to Grimes et al discloses a wound core, the edges of which are thermally sprayed with an electrically non-conducting material.

A fabrication process for forming amorphous metal cores for a transformer is disclosed in United States Patent No. 4,413,406 issued to Bennett et al. Four metal sheets are disclosed which are adjacent to each other and are heat bonded together with a metallic bonding agent. The bonded composite sheet is cut transversely of its length with packets of predetermined length. The width of the packet may be increased.

United States Patent Nos. 3,283,281 issued to Stein et al; 3,156,886 issued to Sutherland and 3,015,791 issued to Rolf disclose laminated layers for transformer cores which have conventional electrical steel members of differing lengths in the adjacent layers.

The use of epoxy resin to insulate magnetic thin films from each other is disclosed in United States Patent No. 4,845,454 issued to Watanabe et al.

United States Patent No. 3,606,676 issued to Kohler discloses silicate bonding of magnetic cores wherein a silicon steel strip is coated with a silicate solution and dried prior to or after winding into a core.

United States Patent No. 4,387,508 issued to Wyatt discloses an apparatus for magnetically assembling transformer cores.

United States Patent No. 4,277,530 issued to Miller discloses adjacent sheets of electrical steel bonded by an adhesive. The adhesive is characterized by rapid

wiring at a temperature of less than 750°F.

Additional related references of which the applicant is aware are as follows:

Inventor(s)	U.S. Patent No.
Schuh	2,280,981
Ford	2,372,074
Amidon	2,390,863
Blessing	2,423,869
Foster	2,484,215
Young	2,493,609
Nagel et al	2,501,349
Nagel	2,554,262
Ford	2,579,560
McBride	2,739,085
Trigg et al	2,904,875
Arntzen et al	2,909,741
Mittermaier et al	3,513,523
Denyssen	3,558,396
Foster et al	3,670,278
Foster et al	3,919,348
Schroeter et al	3,924,022
Schroeter et al	4,032,673
Lichius	4,085,347
Miller	4,277,530
Hiromae et al	4,288,492
Lin	4,445,105
Ettinger et al	4,479,104
Sattler et al	4,481,258
Buckley	4,503,605
Shigeta et al	4,558,297
Perschka et al	4,564,998
Su	4,618,632
Ballard	4,789,849.

Summary of the Invention

In accordance with the teachings of the present invention, there is disclosed a laminated amorphous metal strip including a first strip of amorphous metal having a width, and a second strip of amorphous metal having a width greater than the width of the first strip. The first strip is disposed adjacent to the second strip and is in a first plane with the second strip to form a first layer. A second layer is disposed above the first layer. The second layer has a third strip of amorphous metal which has a width substantially the same as the width of the second strip. The second layer further has a fourth strip of amorphous metal which has a width substantially

the same as the width of the first strip. The third and fourth strips are disposed adjacent to one another and in a second plane. The disposition of the third and fourth strips is the reverse order of the disposition of the first and second strips such that the strips of the second layer overlap the strips of the first layer in a staggered arrangement. A plurality of layers are stacked in an alternating sequence of layers such that every other layer of the sequence is equivalent to the first layer. Every alternating layer of the sequence is equivalent to the second layer. A flexible polymeric bonding material is disposed between each layer of the amorphous metal strip. The polymeric bonding material provides mechanical bonding between the strips in the same layers and between the strips in the adjacent layer. The polymeric bonding material further reduces eddy current losses.

In further accordance with the teachings of the present invention there is disclosed a device for forming a laminated strip of amorphous metal. The device includes a first roll and a second roll of amorphous metal strips. The strips of each roll have an equal width. Also included are a third and fourth roll of amorphous metal strips. The strips of each roll have an equal width. The width of the strips of the third and fourth rolls are wider than the width of the strips of the first and second rolls. Means are provided for unrolling the first roll and the wider third roll such that the strips of the first roll are positioned side-by-side with the strips of the third roll. The strips further have a top surface. Means are provided for applying a polymeric bonding material to the top surface of the strips of the first roll and the third roll. Also, means are provided for unrolling the second roll and the wider fourth roll such that the strips of the second roll are positioned side-by-side with the strips of the fourth roll. Further, the wider strip is in the

reverse order of the position of wider strip of the first and third strips. Means are provided for positioning the side-by-side strips of the second and fourth rolls on the polymeric bonding material on the surface of the strips of the first and third rolls at a pressure point. The wider strips overlap and a brickwork cross section pattern is formed. The strips are bonded into a single laminated strip which has a width substantially equal to the combined widths of the first roll and the third roll. Means are provided for advancing the laminated strip. Means are provided for cutting the laminated strip to a desired length.

Viewed in another aspect, the present invention provides a method of fabricating laminated strips of amorphous metal. This method includes the steps of providing a first roll and a second roll of amorphous metal strips, the strips of each roll having an equal width. A third roll and a fourth roll of amorphous metal strips are provided. The strips of each roll have an equal width. The width of the strips of the third roll and the fourth roll are wider than the width of the strips of the first roll and the third roll. The first roll and the wider third roll are unrolled such that the strips of the first roll are positioned side-by-side with the strips of the third roll, the form of a first layer. The layer further has a top surface. A polymeric bonding material is applied to the top surface of the layer of the first roll and the third roll. The second roll and the wider fourth roll are unrolled such that the strips of the second roll are positioned side-by-side with the strips of the fourth roll, to form a second layer. The wider strip is in the reverse order of the position of the wider strip of the first and third strips. The side-by-side strips of the second and fourth rolls are positioned on the polymeric bonding material on the surface of the strips of the first and third rolls at a pressure point. In this manner, the wider strips overlap

and a brickwork cross section pattern is formed. Pressure is applied to the pressure point to bond the first layer to the second layer to form a single laminated strip having a width substantially equal to the combined widths of the first roll and the third roll. the laminated strip is advanced. The laminated strip is cut to a desired length.

These and other objects of the present invention will become apparent from a reading of the following specification, taken in conjunction with the enclosed drawings.

Brief Description of Drawings

Fig. 1 is a perspective view showing strips of amorphous metal of differing widths in a side-by-side position.

Fig. 2 is a perspective view of Fig. 1 showing the polymeric bonding material applied to the surface of the amorphous metal strips.

Fig. 3 is a perspective view of Fig. 3 showing a laminate of strips of amorphous metal disposed on the bonding material of Fig. 2 illustrating the reverse order of the wider strips.

Fig. 4 is a schematic view showing the device for forming the laminated amorphous metal strip.

Fig. 5 is a sequence diagram showing the method of fabricating the laminated amorphous metal strips.

Best Mode(s) for Carrying Out the Invention

With reference to Fig. 1, there is illustrated a first strip of amorphous metal 11 which is disposed adjacent (side-by-side) a second strip of amorphous metal 12 to form a first layer 13 in a first plane. The second strip 12 has a width greater than the width of the first strip 11.

As shown in Fig. 2, a polymeric bonding material 14 is applied to the top surface of the strips 11 and 12

which constitute the first layer 13 of Fig. 1.

As shown in Fig. 3, a second layer 15 of strips of amorphous metal is disposed above the first layer 13 with the polymeric bonding material 14 therebetween. The second layer 15 has a third strip of amorphous metal 16 disposed adjacent (side-by-side) with a fourth strip 17 of amorphous metal 17. The third strip 16 has a width which is substantially the width of the second strip 12. The fourth strip 17 has a width which is substantially the same as the width of the first strip 11. Thus, the third strip 16 has a width which is greater than the width of the fourth strip 17. The disposition of the third strip 16 and the fourth strip 17 are the reverse of the disposition of the first strip 11 and the second strip 12 with respect to the widths of the respective strips. In this manner, the strips of the second layer 15 overlap the strips of the first layer 13 in a staggered arrangement. This arrangement is similar to a brick work cross-section pattern. As shown in Fig. 3, this alternating sequence of layers may include a plurality of layers, each alternately equivalent to the first layer 13 and the second layer 15 to obtain a desired number of layers of equal widths. A coating of polymeric bonding material 14 is disposed between each adjacent layer.

The nature of the polymeric bonding material 14 is very important. The bonding material 14 serves as an adhesive to provide mechanical support for the component strips and also provides electrical insulation for use of the laminated strips in a transformer. The bonding material 14 must be sufficiently flexible to enable the formed laminate to be used in fabricating a transformer core. Also, in a process to be described, the laminate must have sufficient flexibility to move on a continuous belt conveyor. The bonding material must have a coefficient of shrinkage (or expansion) which is similar to the coefficient of shrinkage (or expansion) of the

amorphous metal. There must be no mechanical stress placed on the brittle amorphous metal. Another important characteristic of the bonding material is its bonding strength, which must be sufficient to assure adherence of the layers to one another. This is accomplished by use of a comparatively thin coating of the bonding material which adheres sufficiently at approximately room temperature and does not require heating to elevated temperatures for bonding of the layers of metal. Further, the electrical properties of the bonding material are a major consideration. The material must not contribute to losses due to eddy currents and hysteresis. These physical and mechanical properties must be considered throughout a wide thermal range to permit operation of the transformer in environmental extremes. In addition, the bonding material must be compatible with dielectric coolants used in transformers.

Among the polymeric bonding materials which have been found to be satisfactory are epoxy resin (epichlorohydrin biphenolate type), neoprene base gasket cement, an electrical grade silicone varnish and an electrical grade silicone grease.

When the transformer core is stacked and not coil wound, the gasket cement may be applied at the interface of the amorphous metal strips which are mated and bonded. After curing, the strip is sheared for core laminations.

The silicone varnish and the silicone grease may be used for laminating strips of amorphous metal which will be coil wound or core stacked. The silicone bonding material is applied at the interface of the amorphous metal strips and the strips are mated. The silicone grease requires no curing and may be used for core wound or core stacked transformers. The silicone varnish, when uncured, provides flexibility for coiling and eliminates coil setting. For core stacking, the laminate bonded with silicone varnish may be sheared, stacked and then cured completely or partially. Alternately, the laminate

bonded with the silicone varnish may be cured, sheared and core stacked.

A device for forming the laminated amorphous metal is illustrated in Fig. 4. A plurality of rolls of amorphous metal (20-23) are mounted on powered uncoilers 24. Each powered uncoiler 24 is controlled by a sonic sensor or similar control means. In a preferred embodiment, two rolls 20, 21 have equal widths and two rolls 22, 23 have equal widths which are wider than the other two rolls 20, 31. The rolls are unrolled such that a strip of roll 20 and a strip of wider roll 22 are positioned side-by-side to form a first layer having a width equal to the sum of the widths of the component rolls 20, 22. When positioned side-by-side, the strips should be as close together as possible; the space between the strips preferably being approximately 0 to 0.030 inches. Each strip has an upper surface and a polymeric bonding material is applied to the upper surface of each roll 20, 22, preferably by means of a spray gun 25. The remaining rolls 21, 23 are unrolled and the strips are positioned side-by-side forming a second layer having the reverse order of the position of the rolls 20, 22 with respect to the wider strip. The strips of rolls 21, 23 are positioned on the polymeric bonding material such that the bonding material is between the first layer and the second layer. Guiding and alignment of each strip through the device is accomplished by supporting the respective strip on rigid flat ramps and aligning the strip with rigid hardened steel bars. The bottom strips 20, 22 are aligned on inside 20, 22. Alignment of the top two strips 21, 23 outer edges is made to the outer edges of the bottom strips 20, 22. In this manner a laminate 27 is formed with the wider strips overlapping in a staggered arrangement like a brick work cross-section pattern. The laminate 27 is pressed at a pressure point 26 to assure satisfactory adhesion of he layers and the bonding

material. The pressure point 26 is curved to effect turns in the travel of the strip such that ironing and compressive forces are eliminated. these forces could result in shear forces between laminations and a fracture of the lamination bonds. The laminate 27 is advanced by a continuous belt drive 30 which has permanent magnets thereon. The laminate 27 is magnetically coupled to the belt. This advancement method exerts an adequate force to drive the device while eliminating undesirable side steering forces which are typically exerted with drive rolls. The laminate 27 is further advanced to an automatic shear 32 means to cut the laminate 27 to a desired length.

The laminate may have more than two (2) layers by applying bonding material to the surface of the second layer and positioning strips in a reverse order to form a third layer and repeating the sequence to obtain a desired number of laminations. In this manner, a laminate having a desired thickness may be obtained.

With reference to Fig. 5, a method of fabricating a laminated strip of amorphous metal is illustrated. First and second rolls of amorphous metal of equal width are provided and third and fourth rolls of amorphous metal are provided having equal widths, the widths being wider than the first and second rolls. The rolls are unrolled by means of powered uncoilers on the respective rolls. The payoff of the roll is controlled by a sonic sensor or other means known to persons skilled in the art. The respective first and third rolls are unrolled to provide a first strip side by side with a wider third strip to form a first layer. The respective strips have a top surface on which is applied the bonding material. Preferably, spray guns are used to spray the bonding material uniformly on the top surface of the first layer. The respective second and fourth rolls are unrolled to provide a second strip side-by-side with a wider fourth strip to form a second layer. The wider strip in the

second layer is in the reverse order of the wider strip of the first layer. The wider strips in the adjacent layers overlap and a brickwork cross-section pattern is formed. Pressure is applied at a pressure point to securely bond the first layer to the second layer and form a single laminated strip having a width equal to the combined widths of the first roll and the second roll. Alternately, the laminate may be formed of plurality of layers with a coating of bonding material between the adjacent layers. A desired number of layers may e obtained. Each respective adjacent layer has an overlap of wider strips such that the brickwork cross-section pattern is formed in the laminate. The laminate is advanced by a continuous belt which has permanent magnets thereon. The laminate is magnetically coupled to the belt. A shearing means is provided which cuts the laminated strip to a desired length.

Obviously, many modifications may be made without departing from the basic spirit of the present invention. Accordingly, it will be appreciated by those skilled in the art that within the scope of the appended claims, the invention may be practiced other than has been specifically described herein.

Industrial Applicability

Amorphous metal is becoming more widely used in the fabrication of transformer cores because of the improved electrical properties of this material compared with the regular grain-oriented electrical steel. However, the amorphous metal is usually available only in rolls of relatively thin sheets having a narrow width. To fabricate a transformer core, a number of such sheets must be layered to achieve a strip of the proper thickness. Likewise, the layered strips must be combined to achieve the proper width. These requirements introduce additional complexities in the fabrication process. For instance, binding materials used in the

lamination of these relatively narrow strips must have electrical and mechanical properties which are compatible with amorphous metal and with other components of the transformer so as not to degrade the performance of the transformer. Also, a more complex apparatus is required to economically and efficiently assemble the transformer components. The present invention resolves these problems. Accordingly, it is a primary object of the present invention to provide a device capable of laminating strips of amorphous metal having differing widths into a bonded laminate which can be cut to desired lengths.

It is a further object of the present invention to provide a laminated strip of amorphous metal having members of differing widths in the individual layers of the laminate.

It is still a further object of the present invention to provide a polymeric bonding material to bond the laminated amorphous metal strips while retaining the significant electrical properties of the amorphous metal.

It is another object of the present invention to provide a method for fabricating laminated strips of amorphous metal.

Claims

1. A laminated amorphous metal strip for use in a transformer core comprising:

a first strip of amorphous metal having a width, a second strip of amorphous metal having a width greater than the width of the first strip, the first strip being disposed adjacent to the second strip and in a first plane with the second strip to form a first layer;

a second layer disposed above the first layer, the second layer having a third strip of amorphous metal having a width substantially the same as the width of the second strip, the second layer further having a fourth strip of amorphous metal having a width substantially the same as the width of the first strip, the third and fourth strips being disposed adjacent to one another and in a second plane, the disposition of the third and fourth strips being the same order of the disposition of the first and second strips such that the strips of the second layer overlap the strips of the first layer in a staggered arrangement;

a plurality of layers stacked in an alternating sequence of layers such that every other layer of the sequence is equivalent to the first layer, every alternating layer of the sequence being equivalent to the second layer; and

a flexible polymeric bonding material disposed between each layer of the amorphous metal strips, the polymeric bonding material providing mechanical bonding between the strips in the same layer and between the strips in the adjacent layer.

2. The laminated strip of claim 1, wherein the respective layers have a plurality of strips in a respective plane to have a desired width, the widths of each alternate layer being substantially the same as the width of the adjacent layer thereto.

3. The laminated strip of claim 1, wherein the

flexible polymeric bonding material is selected from the group consisting of an epoxy resin, a neoprene base gasket cement, a silicone varnish, and a silicone grease.

4. The laminated strip of claim 1, wherein the polymeric bonding material has a coefficient of shrinkage of between 5×10^{-6} °C.

5. The laminated strip of claim 1, wherein the polymeric bonding material is compatible with transformer coolants including transformer oil and silicone fluid.

6. The laminated strip of claim 1, wherein the polymeric bonding material is flexible over a thermal range of between 25°C to 150°C.

7. The laminated strip of claim 1, wherein the polymeric bonding material provides bonding at room temperatures of between 15°C to 35°C.

8. A laminated amorphous metal strip comprising:

a first layer having at least two strips of amorphous metal, disposed side-by-side, a first strip having a width, a second strip having a width greater than the width of the first strip;

a second layer disposed above the first layer, the second layer having a third strip of amorphous metal having a width substantially the same as the width of he second strip, the second layer further having a fourth strip of amorphous metal having a width substantially the same as the width of the first strip, the third and fourth strips being disposed adjacent to one another and in a second plane, the disposition of the third and fourth strips being the reverse order of the disposition of the first and second strips such that the strips of the second layer overlap the strips of the first layer in a staggered arrangement;

a plurality of layers stacked in an alternating sequence of layers such that every other layer of he sequence is equivalent to the first layer, every alternating layer of the sequence being equivalent to the second layer;

a flexible polymeric bonding material disposed between each layer of the amorphous metal strips, the polymeric bonding material providing mechanical bonding between the strips in the same layer and between the strips in the adjacent layer; and

the polymeric bonding material having a coefficient of shrinkage similar to a coefficient of shrinkage of the amorphous metal, the polymeric bonding material retaining flexibility over a wide thermal range.

9. A laminated strip of amorphous metal comprising:

a first strip of amorphous metal having a surface, a second strip of amorphous metal;

a polymeric bonding material applied to the surface of the first strip of amorphous metal; and

the second strip of amorphous metal disposed on the bonding material such that the second strip is bonded to the first strip.

10. The laminated strip of claim 9, wherein the polymeric bonding material is selected from the group consisting of an epoxy resin, a neoprene gasket cement, a silicone varnish and a silicone grease.

11. The laminated strip of claim 9, wherein the polymeric bonding material is flexible over a wide thermal range.

12. The laminated strip of claim 9, wherein the polymeric bonding material has a coefficient of shrinkage similar to a coefficient of shrinkage of the amorphous metal.

13. The laminated strip of claim 9, wherein the polymeric bonding material is compatible with a dielectric coolant of the type used in a transformer.

14. The laminated strip of claim 9, wherein the polymeric bonding material provides bonding at approximately room temperature.

15. A laminated strip of amorphous metal comprising:

a first strip of amorphous metal having a surface, a second strip of amorphous metal;

a polymeric bonding material applied to the surface of the first strip of amorphous metal;

the second strip of amorphous metal disposed on the bonding material such that the second strip is bonded to the first strip;

the polymeric bonding material being flexible over a wide thermal range;

the polymeric bonding material having a coefficient of shrinkage similar to a coefficient of shrinkage of the amorphous metal;

the polymeric bonding material being compatible with a dielectric coolant of the type used in a transformer;

the polymeric bonding material providing bonding at approximately room temperature; and

the polymeric bonding material being selected from the group consisting of an epoxy resin, a neoprene gasket cement, a silicone varnish and a silicone grease.

16. A device for forming laminated strips of amorphous metal, the device comprising:

a first roll and a second roll of amorphous metal strips, the strips of each roll having an equal width; a third and a fourth roll of amorphous metal strips, the strips of each roll having an equal width, the width of the strips of the third and fourth rolls being wider than the width of the strips of the first and second rolls;

means for unrolling the first roll and the wider third roll such that the strips of the first roll are positioned side-by-side with the strips of the third roll, the strips further having a top surface;

means for applying a polymeric bonding material to the top surface of the strips of the first rolls and the third roll;

means for unrolling the second roll and the

wider fourth roll such that the strips of the second roll are positioned side-by-side with the strips of the fourth roll, and further such that the wider strip is in the reverse order of the position of wider strip of the first and third strips;

means for positioning the side-by-side strips of the second and fourth rolls on the polymeric bonding material on the surface of the strips of the first and third rolls at a pressure point such that the wider strips overlap and a brickwork cross-section pattern is formed and bonded into a single laminated strip having a width substantially equal to the combined widths of the first roll and the third roll;

means for advancing the laminated strip; and

means for cutting the laminated strip to a desired length.

17. The device of claim 16, wherein the means for applying the polymeric bonding material is at least one spray gun mounted above the strips of the first roll and the third roll.

18. The device of claim 16, wherein the polymeric bonding material is selected from the group consisting of an epoxy resin, a neoprene gasket cement, a silicone varnish and a silicone grease.

19. The device of claim 16, wherein the pressure point is curved to effect turns in the strip travel such that compressive forces are eliminated.

20. The device of claim 16, wherein pressure is applied at the pressure point to bond the first and third strips ad, the second and fourth strips respectively to the polymeric bonding material therebetween.

21. The device of claim 16, wherein the means for advancing the strip is a continuous belt having magnets thereon, the strip being magnetically coupled to the belt.

22. The device of claim 16, wherein the means for unrolling the respective roll of amorphous metal strip is

a powered uncoiler.

23. The d vice of claim 22, wherein the powered uncoiler is controlled by a sonic sensor.

24. A device for forming laminated strips of amorphous metal, the device comprising:

a first roll and a second roll of amorphous metal strips, the strips of each roll having an equal width; a third and a fourth roll of amorphous metal strips, the strips of each roll having an equal width, the width of the strips f the third and fourth rolls being wider than the width of the strips of the first and second rolls;

at least one powered uncoiler for unrolling the respective first roll and the respective wider third roll such that the strips of the first roll are positioned side-by-side with the strips of the third roll, the strips further having a top surface;

at least one spray gun mounted above the strips of the first roll and the third roll for applying a polymeric bonding material to the top surface of the strips of the first roll and the third roll;

at least one powered uncoiler for unrolling the respective second roll and the respective wider fourth roll such that the strips of the second roll are positioned side-by-side with the strips of the fourth roll, and further such that the wider strip is in the reverse order of the position of the wider strip of the first and third strips;

means for positioning the side-by-side strips of the second and fourth rolls on the polymeric bonding material on the surface of the strips of the first and third rolls at a pressure point such that the wider strips overlap and a brickwork cross-section pattern is formed, means for applying pressure to bond the first, second, third and fourth strips into a single laminated strip having a width substantially equal to the combined widths of the first roll and the third roll;

a continuous belt having magnets thereon, the respective strip being magnetically coupled to the belt for advancement of the strip; and

means for cutting the laminated strip to a desired length.

25. A device for forming laminated strips of amorphous metal, the device comprising:

at least two rolls of amorphous strip, each roll having an equal narrow width; at least two rolls of amorphous metal strip, each roll having an equal wide width;

means for unrolling the one of the narrow width rolls and means for unwinding the one of the wide width rolls such that the strip of the narrow width roll is positioned side-by-side with the strip of the wide width roll, the strips further having a top surface;

means for applying a polymeric bonding material to the top surface of said strip of wide width roll and said strip of narrow width roll;

means for unrolling the another of the narrow width rolls and means for unwinding the another of the wide width rolls such that the strip of said wider width roll is positioned side-by-side with said strip of said narrow width roll and further such that said wide strip and said narrow strip are in the reverse order of the wide strip and the narrow strip f the one rolls;

means for positioning the side-by-side strips of the another rolls on the polymeric bonding material on the surface of the strips of the one rolls at a pressure point such that the wider strips overlap and a brickwork cross-section pattern is formed and bonded into a single laminated strip having a width substantially equal to the combined widths of the wide roll and the narrow roll;

means for repeating the unrolling of respective side width rolls and narrow width rolls, the positioning of strips of narrow width rolls side-by-side with strips of wide width rolls, the applying of polymeric bonding

material, and the positioning of strips to form the laminated strip having a desired number of laminations;

means for advancing the laminated strip; and

means for cutting the laminated strip to a desired length.

26. A method of fabricating a laminated strip of amorphous metal which comprises the steps of:

providing a first roll and a second roll of amorphous metal strips, the strips of the first roll and of the second roll having an equal width;

providing a third roll and a fourth roll of amorphous metal strips, the strips of the third roll and of the fourth roll having an equal width, the width of the strips of the third roll and the fourth roll being wider than the width of the strips of the first roll and the second roll;

unrolling the first roll and the wider third roll such that the strips of the first roll are positioned side-by-side with the strips of the third roll to form a first layer, the layer further having a top surface;

applying a polymeric bonding material to the top surface of the layer of strips of the first roll and the third roll;

unrolling the second roll and the wider fourth roll such that the strips of the second roll are positioned side-by-side with the strips of the fourth roll to form a second layer and further such that the wider strip is in the reverse order of the position of wider strip of the first and third strips;

positioning the side-by-side strips of the second and fourth rolls on the polymeric bonding material on the surface of the strips of the first and third rolls at a pressure point such that the wider strips overlap and a brickwork cross-section pattern is formed;

applying pressure to the pressure point to bond the first layer to the second layer to form a single

laminated strip having a width substantially equal to the combined widths of the strips of the first roll and the third roll;

advancing the laminated strip; and

cutting the laminated strip to a desired length.

27. The method as defined by claim 26, which further comprises the step of spraying the polymeric bonding material on the top surface from at least one spray gun mounted above the strips of the amorphous metal.

28. The method as defined by claim 26, which further comprises the step of unrolling the respective rolls using a power uncoiler, the power uncoiler being controlled by a sonic sensor.

29. The method as defined by claim 26, which further comprises the step of advancing the laminated strip by magnetically coupling the laminated strip to a continuous belt having magnets thereon.

30. The method as defined by claim 26, which further comprises forming a laminated strip having a plurality of adjacent layers, each layer having wider strips which overlap the wider strips of the respective adjacent layer.

AMENDED CLAIMS

[received by the International Bureau on 30 July 1991 (30.07.91) ; original claims 3, 5 and 8 amended ; other claims unchanged (3 pages)]

1. A laminated amorphous metal strip for use in a transformer core comprising:

a first strip of amorphous metal having a width, a second strip of amorphous metal having a width greater than the width of the first strip, the first strip being disposed adjacent to the second strip and in a first plane with the second strip to form a first layer;

a second layer disposed above the first layer, the second layer having a third strip of amorphous metal having a width substantially the same as the width of the second strip, the second layer further having a fourth strip of amorphous metal having a width substantially the same as the width of the first strip, the third and fourth strips being disposed adjacent to one another and in a second plane, the disposition of the third and fourth strips being the same order of the disposition of the first and second strips such that the strips of the second layer overlap the strips of the first layer in a staggered arrangement;

a plurality of layers stacked in an alternating sequence of layers such that every other layer of the sequence is equivalent to the first layer, every alternating layer of the sequence being equivalent to the second layer; and

a flexible polymeric bonding material disposed between each layer of the amorphous metal strips, the polymeric bonding material providing mechanical bonding between the strips in the same layer and between the strips in the adjacent layer.

2. The laminated strip of claim 1, wherein the respective layers have a plurality of strips in a respective plane to have a desired width, the widths of each alternate layer being substantially the same as the width of the adjacent layer thereto.

3. The laminated strip of claim 1, wherein the

flexible polymeric bonding material is selected from the group consisting of an epoxy resin, a neoprene base gasket cement, a nitrile base cement, a silicone varnish, and a silicone grease.

4. The laminated strip of claim 1, wherein the polymeric bonding material has a coefficient of shrinkage of between 5×10^{-6} °C.

5. The laminated strip of claim 1, wherein the polymeric bonding material is non-reactive with transformer coolants including transformer oil and silicone fluid.

6. The laminated strip of claim 1, wherein the polymeric bonding material is flexible over a thermal range of between 25°C to 150°C.

7. The laminated strip of claim 1, wherein the polymeric bonding material provides bonding at room temperatures of between 15°C to 35°C.

8. A laminated amorphous metal strip comprising:

a first layer having at least two strips of amorphous metal, disposed side-by-side, a first strip having a width, a second strip having a width greater than the width of the first strip;

a second layer disposed above the first layer, the second layer having a third strip of amorphous metal having a width substantially the same as the width of the second strip, the second layer further having a fourth strip of amorphous metal having a width substantially the same as the width of the first strip, the third and fourth strips being disposed adjacent to one another and in a second plane, the disposition of the third and fourth strips being the same order of the disposition of the first and second strips such that the strips of the second layer overlap the strips of the first layer in a staggered arrangement;

a plurality of layers stacked in an alternating sequence of layers such that every other layer of the sequence is equivalent to the first layer, every

alternating layer of the sequence being equivalent to the second layer;

a flexible polymeric bonding material disposed between each layer of the amorphous metal strips, the polymeric bonding material providing mechanical bonding between the strips in the same layer and between the strips in the adjacent layer; and

the polymeric bonding material having a coefficient of shrinkage similar to a coefficient of shrinkage of the amorphous metal, the polymeric bonding material retaining flexibility over a wide thermal range.

9. A laminated strip of amorphous metal comprising:

a first strip of amorphous metal having a surface, a second strip of amorphous metal;

a polymeric bonding material applied to the surface of the first strip of amorphous metal; and

the second strip of amorphous metal disposed on the bonding material such that the second strip is bonded to the first strip.

10. The laminated strip of claim 9, wherein the polymeric bonding material is selected from the group consisting of an epoxy resin, a neoprene gasket cement, a silicone varnish and a silicone grease.

11. The laminated strip of claim 9, wherein the polymeric bonding material is flexible over a wide thermal range.

12. The laminated strip of claim 9, wherein the polymeric bonding material has a coefficient of shrinkage similar to a coefficient of shrinkage of the amorphous metal.

13. The laminated strip of claim 9, wherein the polymeric bonding material is compatible with a dielectric coolant of the type used in a transformer.

14. The laminated strip of claim 9, wherein the polymeric bonding material provides bonding at approximately room temperature.

STATEMENT UNDER ARTICLE 19

In response to the International Search Report issued on June 24, 1991 in the above-referenced case, please enter the following Amendments under Article 19 and in accordance with Rule 46.

Please amend claims 3, 5 and 8 as follows with additions shown underlined and deletions appearing in brackets:

3. (Amended) The laminated strip of claim 1, wherein the flexible polymeric bonding material is selected from the group consisting of an epoxy resin, a neoprene base gasket cement, <u>a nitrile base cement,</u> a silicone varnish, and a silicone grease.

5. (Amended) The laminated strip of claim 1, wherein the polymeric bonding material is [compatible] <u>non-reactive</u> with transformer coolants including transformer oil and silicone fluid.

8. (Amended) A laminated amorphous metal strip comprising:

a first layer having at least two strips of amorphous metal, disposed side-by-side, a first strip having a width, a second strip having a width greater than the width of the first strip;

a second layer disposed above the first layer, the second layer having a third strip of amorphous metal having a width substantially the same as the width of the second strip, the second layer further having a fourth strip of amorphous

metal having a width substantially the same as the width of the first strip, the third and fourth strips being disposed adjacent to one another and in a second plane, the disposition of the third and fourth strips being the [reverse] <u>same</u> order of the disposition of the first and second strips such that the strips of the second layer overlap the strips of the first layer in a staggered arrangement;

a plurality of layers stacked in an alternating sequence of layers such that every other layer of the sequence is equivalent to the first layer, every alternating layer of the sequence being equivalent to the second layer;

a flexible polymeric bonding material disposed between each layer of the amorphous metal strips, the polymeric bonding material providing mechanical bonding between the strips in the same layer and between the strips in the adjacent layer; and

the polymeric bonding material having a coefficient of shrinkage similar to a coefficient of shrinkage of the amorphous metal, the polymeric bonding material retaining flexibility over a wide thermal range.

REMARKS

Claims 1, 2, 4, 6, 7 and 9-30 are to remain unchanged. A replacement sheet is submitted herewith in accordance with Rule 46.3(a) to replace every sheet of the claims which is affected by the foregoing amendments.

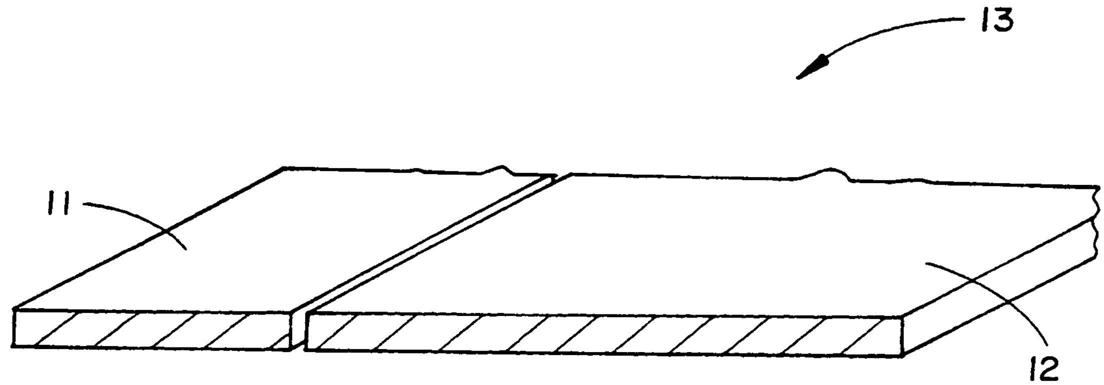

FIG. 1

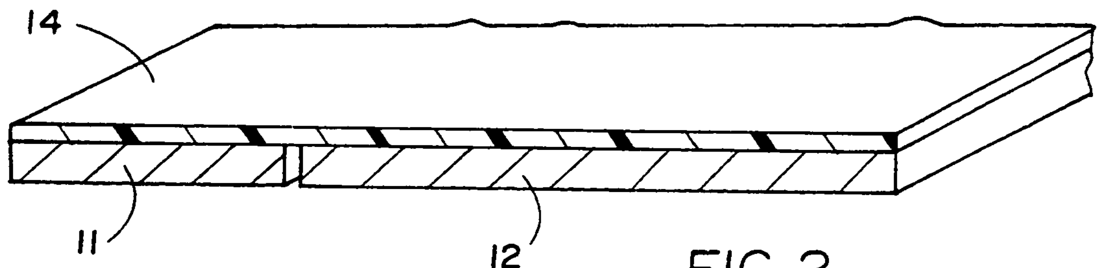

FIG. 2

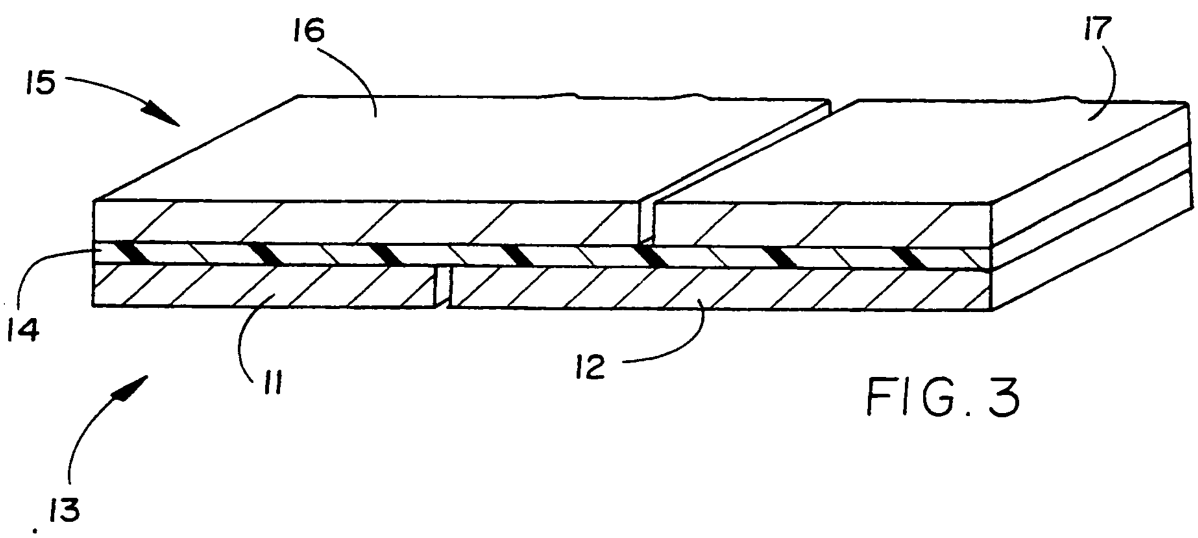

FIG. 3

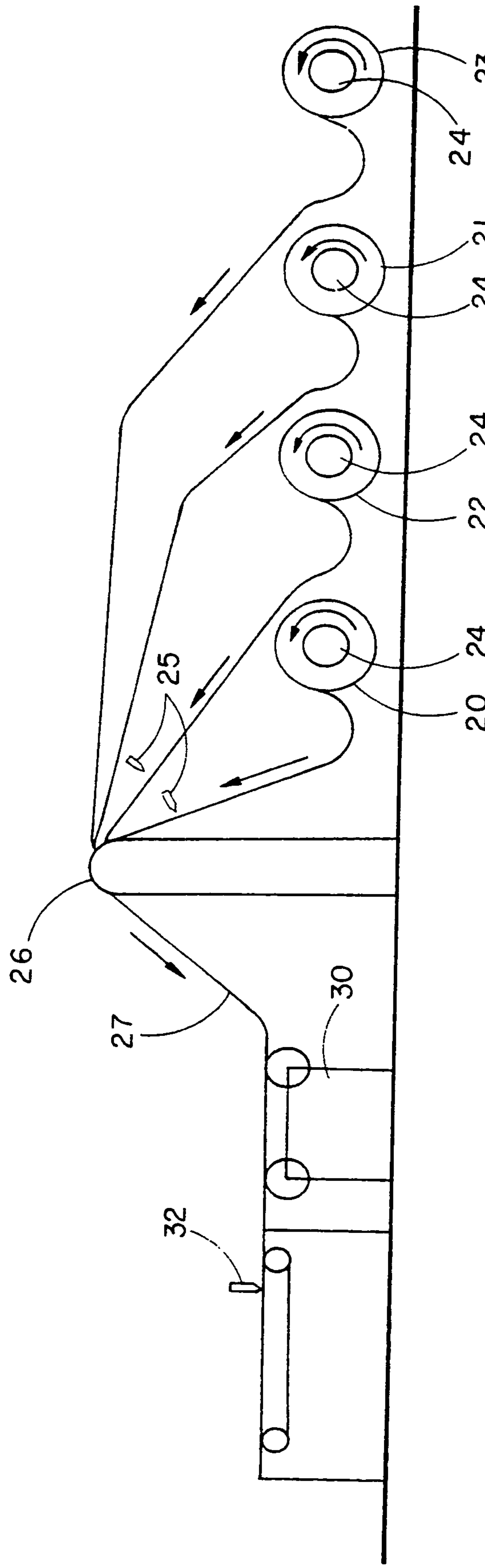

FIG. 4

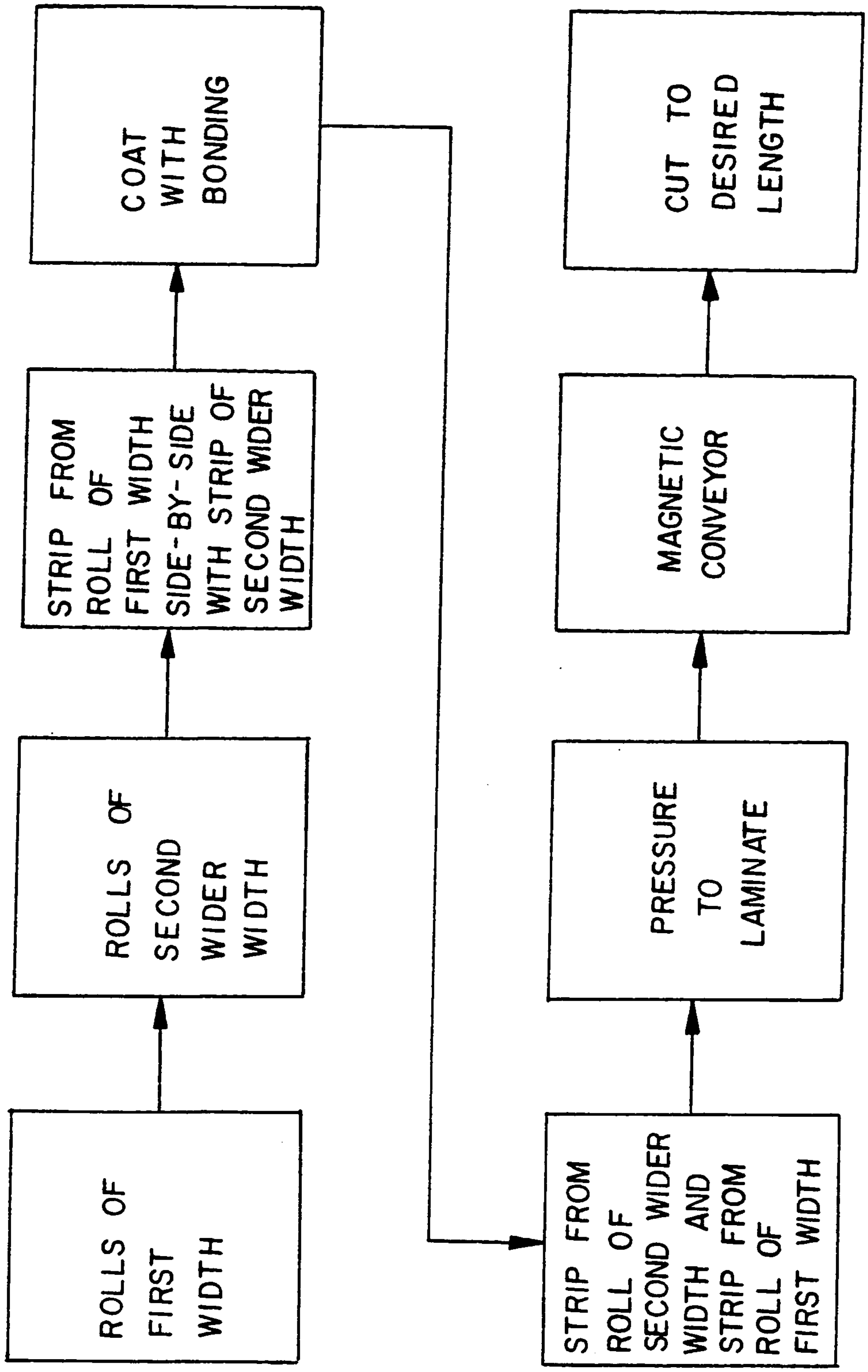
ROLLS OF FIRST WIDTH
ROLLS OF SECOND WIDER WIDTH
STRIP FROM ROLL OF FIRST WIDTH SIDE-BY-SIDE WITH STRIP OF SECOND WIDER WIDTH
COAT WITH BONDING
STRIP FROM ROLL OF SECOND WIDER WIDTH AND STRIP FROM ROLL OF FIRST WIDTH
PRESSURE TO LAMINATE
MAGNETIC CONVEYOR
CUT TO DESIRED LENGTH

FIG. 5

ERNATIONAL SEARCH REP

International Applicatio PCT/US91/01401

I. CLASSIFICATION OF SUBJECT MATTER (if several classification symbols apply, indicate all) [3]

According to International Patent Classification (IPC) or to both National Classification and IPC

IPC (5); B32B 15/04, 31/12, 31/20
U.S.Cl.: 428/626,635,457,458,463; 156/270,324,516,549,558

II. FIELDS SEARCHED

Minimum Documentation Searched [4]

Classification System	Classification Symbols
U.S.	428/622,626,635,457,458,463,593 156/270,304.3,324,516,546,549,551,558

Documentation Searched other than Minimum Documentation to the Extent that such Documents are Included in the Fields Searched [5]

III. DOCUMENTS CONSIDERED TO BE RELEVANT [14]

Category *	Citation of Document, [16] with indication, where appropriate, of the relevant passages [17]	Relevant to Claim No. [18]
X A	US, A, 4,277,530 (MILLER) 07 July 1981 See entire document	9-15 1-8
A	US, A, 4,650,723 (FURUYA) 17 March 1957 See entire document	1-15
A	US, A, 4,749,625 (OBAYASKI ET AL.) 07 June 1988 See entire document	1-15
A	JP, A, 59-11236, (BRIDGESTONE TIRE) 20 January 1984 See abstract	16-30
A	JP, A, 01-206047 (NIPPON STEEL) 18 August 1989 See abstract	16-30
A	US, A, 4,882,834 (SCHOEN) 28 November 1989 See entire document	26, 27

* Special categories of cited documents: [15]
"A" document defining the general state of the art which is not considered to be of particular relevance
"E" earlier document but published on or after the international filing date
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step
"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.
"&" document member of the same patent family

IV. CERTIFICATION

Date of the Actual Completion of the International Search [2]	Date of Mailing of this International Search Report [2]
28 May 1991	24 JUN 1991
International Searching Authority [1]	**Signature of Authorized Officer [20]**
ISA/US	George Wyszomierski

Form PCT/ISA/210 (second sheet) (May 1986)